DOCUMENT RESUME

ED 390 660 SE 057 125

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TITLE The Potential of Distance Learning To Provide Training Opportunities for Teachers of Science in the Primary Curriculum.
PUB DATE Sep 95
NOTE 11p.; Paper presented at the Conasta Conference (44th, Brisbane, Queensland, Australia, September 1995).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS British National Curriculum; *Distance Education; Elementary Secondary Education; Foreign Countries; Higher Education; Knowledge Base for Teaching; Science Teachers; *Teacher Education
IDENTIFIERS England

ABSTRACT

Since 1990, the implementation of the Science at Key Stages 1 and 2 of the National Curriculum in England has exerted a profound impact on the style of inservice training supporting the teaching of science in the primary curriculum. This paper explores the potential of distance learning to deliver inservice training in primary science using evidence from a five year research, development, and training program from the Open University, the Science for Primary Teachers' project. Teachers throughout England participated in this initiative, providing key information through the use of learning files, reflective diaries, questionnaires, and dialogue with course tutors. In addition, teachers produced assignments showing the impact of the science they had learned on their practice. (Author)

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THE POTENTIAL OF DISTANCE LEARNING TO PROVIDE TRAINING OPPORTUNITIES FOR TEACHERS OF SCIENCE IN THE PRIMARY CURRICULUM.

THE EXPERIENCE OF THE SCIENCE FOR PRIMARY TEACHERS PROJECT AT THE OPEN UNIVERSITY, ENGLAND.

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ED 390 660

ABSTRACT

Since 1990, the implementation of the Science at Key Stages 1 and 2 of the National Curriculum in England has exerted a profound impact on the style of In-service training supporting the teaching of science in the primary curriculum. This paper explores the potential of distance learning to deliver In-service training in primary science using evidence from a five year research, development and training programme from the Open University; the 'Science for Primary Teachers' project. Teachers throughout England participated in this initiative, providing key information through the use of learning files, reflective diaries, questionnaires and dialogue with course tutors. In addition, teachers produced assignments showing the impact on their practice of the science they had learned. These led to the award of the 'Certificate in Science for Primary Teachers'.

INTRODUCTION

The National Curriculum for England applies to pupils of compulsory school age in maintained (or state funded) schools. For the primary sector, it is organised on the basis of two key stages:

Key Stage 1 for pupils aged between 5 and 7 in year groups 1 and 2

Key Stage 2 for pupils aged between 7 and 11 in year groups 3 to 6

Science occupies one of the Core Curriculum slots in England, alongside Mathematics and English. Other foundation subjects are technology, history, geography, art, music and physical education.

For each key stage in science, programmes of study set out what pupils should be taught and attainment targets outline the expected standards of pupils performance. These standards are detailed in eight level descriptions of increasing difficulty at the end of key stages 1 and 2.

Similar structures are in place for the Curriculum at ages 11 to 16.

Science at key stages 1 and 2 was implemented for the first time in 1990. Since then the requirements of the National Curriculum have been subject to considerable revision. Introducing an obligation on primary teachers to deliver the legally defined entitlement in science to all primary aged children has exerted a profound impact on them. Many primary teachers have limited qualifications and knowledge in science. Historically very little science was included in the primary classroom and this was especially true of the physical sciences. Therefore the style of In-service training needed to support the teaching of science in the new climate was radically different.

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Prior to the introduction of National Curriculum Science, at the stage of the Interim Report of the Working Party (1988), staff at the Centre for Science Education (CSE) at the Open University (OU) began identifying needs of primary teachers raised by the nature of National Curriculum Science at Key Stage 1 and 2 as proposed in the Working Party Report. A pilot scheme was devised, funded by the DES with additional monies from National Power Plc and Nuclear Electric Plc, to investigate the potential for meeting these needs by drawing on and adding to materials from the Science Foundation Course. It was envisaged that participating teachers would use these distance learning materials within a tutorial programme that required around 20 days release over the course of an academic year. Extensive collaboration between the Open University and Local Education Advisory support science staff would be essential in the provision of the tutorial programmes, and generation of appropriate teaching materials.

The initiatives devised to support the pilot scheme were extended with the launch of the national 'Science for Primary Teachers' (SPT) project in the following year.

WHY CHOOSE THE SCIENCE FOUNDATION COURSE AS A STARTING POINT?

The Science for Primary Teachers project was aiming to make a response to the research findings of Tobin and Garnett (1988) who, in their documentation of exemplary practice in science classrooms found that while primary teachers could manage the classroom, get activities in science started, monitor their pupils engagement, and probe children's thinking they experienced severe difficulties with:

- assisting pupils to develop the science content from the classroom curriculum;
- could not ask the crucial questions to focus children's thinking on what was learned;
- did not always know what children were supposed to learn from an activity;
- diagnosing partial understanding and misunderstandings from children's responses;
- failed to focus on content and concept development.

OU experience convinced the Project Team that sustained improvement in primary practice in science could be enhanced through teachers acquiring a comprehensive knowledge base in science. In order to meet the challenges outlined above, this would require a substantial initial effort on the part of participating teachers and skilful tutoring in a relaxed and non-threatening environment by tutors experienced in dealing with adult learners.

The Science Foundation Course is a multi-disciplinary course written for adult learners who have little or no scientific or mathematical background knowledge. During the lifetime of the OU it has introduced many thousands of adults to science at a challenging and exciting level. Indeed, many students of the course have been teachers at both secondary and primary level who have gone on to complete a degree in science. However, it is widely recognised amongst Open University students and tutors that the Science Foundation Course (S102) is a demanding one, and in basing an In-Service Education Course for Teachers (INSET) on certain units of S102, primary school teachers would be faced with similar challenges (but also rewards). Also to be faced was the issue of immediate relevance of the course programme and materials to work with young children. Prior to the introduction of National Curriculum Science, when primary teachers attended courses, they expected to take away with them ideas that they could immediately use in the classroom, but having gained little or nothing of a personal knowledge of science. Now, with science at Key Stages 1 and 2 in the National Curriculum the demands on their own knowledge and understanding of science would be increased substantially.

So, a major challenge of the course was to convince participating teachers of the validity of its *long term* aims and to encourage them to believe that they could acquire a personal knowledge of science at their level. This project aimed to explore the validity of the potential of a course which invested in the intellectual capital of the teacher. This would be by enabling them to

develop a sound framework in science which would become the basis for developing future science curriculum and teaching in the primary classroom.

A COLLABORATIVE RELATIONSHIP BETWEEN THE OPEN UNIVERSITY AND LEAs.

A series of new booklets called *Study Commentaries* were planned to address the challenges outlined above and to guide teachers through those aspects of the Science Foundation Course which had central relevance to teaching science in the primary school. This provided the first opportunity for collaboration; in teams of two or three, authors were established to generate each of the required study commentaries. These authoring teams were under the overall direction of the two directors who were also the academic editors for the project, Susan Tresman and Linda Hodgkinson.

Teachers were given 'study notes' where the science was explained to them at an adult level; these were accompanied by 'teaching notes' written by teacher authors and included guidance on effecting the translation of newly acquired science to the classroom. This translation was achieved by a variety of suggestions for activities, investigations, management of the classroom, starting points for topics, questioning techniques, advice on how children learn certain concepts, opportunities to consider continuity and progression of learning in science and assessment and recording of childrens' achievements.

Collaboration in the production of the course materials was only the first step in realising the aims of the project. It was recognised that the key to the successful implementation of training programmes based around the materials hinged on harnessing the areas of expertise of the OU and the Advisory Teams of the Local Education Authorities (LEAs).

PATTERNS OF TUTORIAL PROVISION

In most cases, the programmes of tutorial provision resulted from detailed planning meetings between the Project Directors and the Advisory Teams. A varied menu of INSET activities were devised which incorporated elements of exposition about science, generally undertaken by OU tutorial staff and varied opportunities for practical work at the level of the teacher and also to experience suitable investigations for the classroom - often team taught by OU and LEA staff. Discussion, planning for schemes of work, field visits, use of OU video materials, presentations to invited audiences, quizzes etc., all played a part in mediating the course materials to course members.

A general consensus was reached on the length of time required to study the course materials and attend tutorial sessions - this was around 20 days of study time away from the classroom. Some of these days were allocated to private study of the distance learning materials. Tutorial or private study sessions were spaced approximately a week apart and spanned two or three terms.

Full scale collaboration occurred in the generation of the assignment material between the LEA Advisory Teams and the Project Directors. The assignments afforded a focus for school based action research into aspects of children's learning in science, planning schemes of work, evaluation of science within the curriculum and developing a school policy for science. The aim was to produce assessments which were of practical use to the schools students worked from as well as being valuable to the students as individuals. They prompted the development of 'research tasks' carried out in school, such as, assessing and indexing resources, looking at the purposes of display, organising the classroom for practical work in science, promoting safe science. An example of a training programme based on SPT materials and Local Education Authority tutorial support is shown in table 1.

Table 1
An example of a training programme based on the SPT materials

Type of session	Programme
Term 1	
2 days	What is science, what sciences are there? What are public perceptions of science How do scientists gain new knowledge? Earth in space Practical work in science The science process in investigations
1 day	Forces 1 Safety in science The role of the science coordinator 1
1 day	Forces 2
1 day (day 5)	Earth science 1, studying the ocean floor Magnetism, the earth as a magnet Volcanoes and earthquakes Plate tectonics Curriculum planning
1 day	Introduction to energy Electricity The role of the science coordinator 2
Twilight	The role of the coordinator 3
School-based	Work in support of assignments for the Certificate in Science for Primary Teachers Assessing the understanding of children in given topic area
2 days	Energy Light and sound and music
1 day (day 10)	Presentations by teachers Science is magic! Feedback on first assignment
Term 2	
2 days	Chemistry in the kitchen Simple atomic structure Chemical reactions and chemical change Teaching and learning chemistry through topic work The role of the coordinator 4
1 day	Making a shower gel - a project developed by the OU in conjunction with Unilever plc.
Twilight	The role of the coordinator 5
1 day (day 14)	Evolution and the variety of life Inheritance of characteristics
2 days	Ourselves - our bodies DNA - an introduction to the fabric of life Ecology and the environment

1 day (day 17)	Earth Science 2 - understanding rocks, soils, fossils, geological time scales
School-based	Managing school-based INSET in science Working with colleagues in science
2 days	Weather - construction of school weather station and nature area Mounting exhibition of course work 5-minute presentations (Headteachers invited) outlining one aspect of learning science as an adult and how it changes potential for science in the classroom Social finale

PARTNERSHIPS LEADING TO THE AWARD OF THE PROFESSIONAL CERTIFICATE

Each group of 10 or more participating teachers in the National project was assigned a group coordinator from the Open University who were either members of the SPT Course Team or Science Foundation Course tutorial staff who had been given training to work on this course. They worked alongside the LEA staff, in the planning, administration, evaluation and delivery of the course. Either the group coordinator but more generally the LEA tutor was appointed as assignment tutor to offer support and advice to teachers completing their assessments, and to provide feedback on the completed work. Assignment tutors were supported by training, tutor notes to provide support and guidance for marking scripts, and monitoring of their marking of students work.

The Open University 'Certificate in Science for Primary Teachers' (the first certificate course from the Science Faculty) was launched in 1990. Awards were made on the basis of the successful completion of three summative assignments, as described above.

EVALUATING THE POTENTIAL FOR TRAINING

Course leaders of the various SPT courses running in different areas of the country provided a variety of opportunities for monitoring and formative evaluation of the sessions.

These included diaries which allowed participants to reflect on their experiences each week and to share these reflections with each other. These shared reflections then formed part of the basis for progression through subsequent weeks of the tutorial programme. Other forms of reflection included personal files with entries at intervals, e.g. before starting the assignments, during work on them, on their completion and then on receipt of the marks for these assignments.

Questionnaires were also used to shape and replan/amend tutorial programmes at the start of each term or half term. Thus a range of techniques were established for integrating reflection with action, which would promote maximum flexibility of tutorial provision and allow for modifications to the pace, timing or content of sessions, if necessary. In most cases, on-going planning sessions were carried out by OU and LEA staff at the start of each term to incorporate and introduce agreed changes. Such opportunities for reflection allowed course members to take some control of the consequences of their reflections (Tresman and Edwards, 1993).

The following case study focuses on one SPT course in particular, where reflective dairies were used to assess the potential of a distance learning course to meet the perceived needs of participating teachers.

Table 2 is a summary of a full analysis of the diary responses from all 10 course members over the 11 sessions, on which diaries were completed.

There were 67 expressions of concern, 26 complaints or suggestions for improvement and 140 positive statements. Such crude numerical scores do not presume that all statements are of equal significance, but they do indicate that, whilst the course members had a number of real concerns, there was still plenty in the course for them to feel good about.

Table 2. The occurrence of the eight different categories of response through the 11 sessions when dairies were complete.

	Sessions											
	1	2	3	4	5	6	7	8	9	10	11	Total
Concerns												
Workload and time	3	4					3				1	11
Difficulty of material	11	4		2	2	2	5				2	28
Relevance to school	5			4		4		1				14
Assignments	4	2		3			1	4				14
Complaints/suggestions: related to organisation and presentation of sessions		7		1	7	2	7		1		1	26
Positive statements: Personal development/ learning from science	6	8	17	2	5	2	13		3		1	57
Relevance to school		4	12	2	2	2		5	8	1	3	33
Organisation/ presentation of sessions and materials	2	6	3	10	7		1	7	8	9	5	50

There appeared to be two central areas of concern:

Difficulty

Basic science is very difficult for people who have very limited formal background in science.

The difficulty has two forms. First, some of the fundamental concepts are difficult because they are abstract and often counter-intuitive. A good example of this is the concept of force. Intuitively, people feel that a force is needed to keep things moving. It is counter -intuitive to learn that things carry on moving at the same rate in the absence of any force (or when forces are balanced) and that they only slow down and stop because a force is applied. This makes it very difficult to understand motion under gravity and around corners. The second reason for the difficulties is the sheer amount and diversity of knowledge involved in a basic understanding of science. It was not lost on these teachers that *three* different scientists were employed to introduce the basic ideas of the different branches of science - even at their level. However, all branches of science were not perceived to be equally difficult. Geology and biology were perceived as being easier and more relevant than physics and chemistry. Might that be something to do with the gender balance of the group? It was predominantly female - as are most primary school teachers.

We cannot pretend that science is easy, but we can help people to feel more comfortable with their difficulties - for example a comment from Session 8: 'We seem more comfortable together as a group and able to ask questions without feeling ridiculous'.

Applicability

Teachers are able to appreciate that there is value in learning the fundamental concepts and that these will not always seem to be immediately relevant in the classroom. Nevertheless, applicability remains an extremely potent motivating agent - and conversely a lack of applicability tends to be demotivating. This led to an increased tendency during the course to start with children's experience and to derive basic scientific principles from it, rather than to start with the scientific principles and then show how these relate to experience. This is simply an application to the pedagogic and scientific principles of proceeding from the particular to the general, from the evidence to the theory: 'Today... something *real* to me. We can relate to our physical features and surroundings. I feel safer learning from something which makes sense to me'.

A series of end-of-course evaluations were conducted by the Project Directors. These were analysed to look at three issues in particular;

Background knowledge in science

The rigorous background knowledge across a wide range of science topics was valued very highly. Teachers talked of classroom-based knowledge about the teaching of science being available at all times, whereas the 'real' science wasn't. They reflected positively on the fact that the science was at the level of the adults, that they found the academic study challenging and enjoyable. Some teachers talked of the need to absorb science knowledge first and then to learn how to apply it. They enjoyed the tutorials which explained specific scientific concepts in the company of experienced tutors of adult learners. The hugely important non-threatening nature of the learning environment of the teachers was emphasised by remarks such as
'...the tutor was excellent at answering questions and never made you feel an idiot.'
'Good course with highly approachable very knowledgable tutors.'
'...teachers are professionals and deserve to have good courses.'
'...the written OU resources were excellent.'
Some teachers itemised specific concepts in their evaluations such as
'...forces and gravity - I now know the difference between mass and weight!'

The degree of commitment required by the teachers to complete such a course of study was also revealed in the evaluations. A high proportion of teachers commented on the large amount of time they needed to commit to their study and the high degree of organisation needed to synthesize their study, to reflect on the use of the science in the classroom; to try out ideas in the classroom and to develop work for assignments alongside everything else.

However despite reservations expressed about time commitments, the potential for such a training course to transform the perspectives of primary teachers is revealed by the following comment from a teacher of reception aged children;
'I now know even when teaching at a basic level, the concepts that the children are leading towards eventually.'

Using the science in school

A course with this degree of science appears to give teachers the intellectual competence in science to change the emphases of topics in the primary curriculum so as to focus more explicitly on science, particularly in the area of chemistry. Teachers were also more able to make new links within and between topics and year groups and to improve the planning and recording of science. They were inspired to tackle areas which they had previously avoided with increased confidence and awareness. Teachers told of having many more ideas for investigations. Given the crucial importance of appropriate teacher intervention and questioning techniques to advance children's understanding in science, it was highly significant that teachers spoke of being more able
'to listen more to children and what they know and to answer their questions'

In terms of working with colleagues teachers spoke of gaining the confidence to answer other teacher's questions and to support others using resources from the course. They felt more able to run INSET days in science which were well received, to learn the value of shared reflections and to establish contact groups amongst course participants after the end of the course. A couple of illustrative comments are,
'I was able to pass on a mass of useful information.'
'Although it has been hard work it has been rewarding.'
'It is amazing the knowledge I have picked up and can feed back.'

Use of assignments in promoting a review of classroom practice

Turning now to the value of working on classroom-focused assignments, the following comments were significant in highlighting how a knowledge of science can promote a fundamental review of classroom practice.
'The assignments gave me an opportunity to focus in - to reflect on what I do in my own classroom, to analyse what is done and why.'
'...the assignments stimulated deep thinking on the scientific content behind the classroom work, focusing my attention on the specific learning objectives of the activities.'
'...caused me to ask myself, am I getting results, are the children learning?'

Teachers commented on how they now planned for investigative work in science, whereas before they took it for granted that it was covered by whatever they were doing. Completing the assignments made teachers really consider progression and the scientific background to the activities taking place in their classrooms.

From a consideration of teachers' evaluations it also became clear that many viewed the production of assignments with trepidation to begin with, and required a good deal of support from course tutors and colleagues to commit their ideas about science and the teaching of science to paper for assessment.

Receiving back positive comments and constructive criticisms from the tutor responsible for marking the assignments provided a major boost to participants' confidence about relating newly-acquired knowledge in science to their classroom practice.

OUTCOMES OF THE PROJECT

Science for Primary Teachers can make a significant contribution to meeting the required outcomes for realising the potential of primary science according to authors such as Tobin and Garnett (1988) and contains many of the elements listed by Bolam (1988) and in Steadman et al, report to the DFE: INSET effectiveness (1992). These elements are summarised in Table 3.

Table 3
Effective training programmes in primary science

Requirements of an effective training programme in primary science e.g. Bolam (1988)	How these needs are met by the Science for Primary Teachers Course
Collaborative relationship between providers, participants, LEAs and schools	Detail planning and liaison between SPT Course team and clients; cross fertilisation of ideas, sharing of expertise built up by working with LEAs in various parts of the country
Needs-based course design	Negotiation of tutorial provision between CSE and LEA Advisory team. Audit of participant's needs and skills prior to the start of the course
Presentation of sufficient science content to support KS1 and 2 Science	Study of relevant aspects of S102, as directed by the study commentaries; teaching about science through written and verbal means which leads to a change in teachers' core constructs. Teaching occurs in a non-threatening tutorial environment, backed up by high quality distance learning (SPT) resource materials.
Opportunities for work in practical science for investigating classroom application and to participate in exploratory workshops	Incorporation of workshops and exhibits based on collaboration with industry, science projects, museums etc. Practical work in tutorials based on study commentaries is enhanced by material produced by Advisory Teams responsible for course tuition
To help locate science in the broad curriculum of primary education and to develop proficiency in establishing cross-curricular links	Blending pedagogical expertise of advisory teams and science expertise of OU tutors in adult learning at a distance and informal tutorial frameworks
Opportunity to reflect on impact of science training to work in the classroom	Execution of action research tasks in the distance learning texts resulting in the production of handouts about work in school for resource sharing. Production of assignments which are classroom focused
To equip teachers with the skills needed to assess the progress and attainment of pupils in science	A focus on assessment and records of achievement occurs within the course. This is backed by discussion papers contained with the SPT resources and designed to be used in a distance learning mode
Opportunities for evaluation of the course	Use of reflective diaries and evaluation sheets
To equip teachers with the knowledge to plan and prepare schemes of work in science and to provide for progression and continuity within and between key stages	Through the study of distance learning materials in conjunction with face-to-face tuition, the course equips teacher with sufficient knowledge to 'see' the end points of the various levels of attainment and Programmes of Study (POS). This helps them to teach in such a way as to help pupils to avoid the misconceptions and partial understandings which are so damaging when concepts are revisited at a subsequent level or key stage

It has been particularly gratifying to see the extent to which LEA Advisory Teams can develop the expertise, confidence and motivation to take increasing levels of responsibility for running programmes of science training based on SPT materials, that qualify for designation and receive mainly positive evaluations from course participants and Headteachers alike. These evaluations show that teachers are able to appreciate that there is a value in learning the fundamental concepts of science, and will accept that these may not always be immediately relevant to the classroom. However, relevance, be it short, medium or long term, to the primary curriculum remains an important motivating factor and needs to be given a high profile in course materials and stressed by tutors throughout the course.

MOVING ON: THE NEW (1995) COURSE, PRODUCED IN COLLABORATION WITH BBC EDUCATION; 'PRIMARY TEACHERS LEARNING SCIENCE'.

In 1994, the opportunity arose for the CSE to work in collaboration with the British Broadcasting Corporation: Education Division on a new primary science project. This provided the means of incorporating the revisions to the Science National Curriculum that had been introduced by the Department for Education between 1990 and 1994.

The new project includes a substantial amount of broadcast resource for Pupils and Teachers, complemented by science kits, books, teachers' files and programme notes. A new course has also been produced from the Open University, linked to the overall project, to provide training opportunities for teachers. Much of what was learned from the Science for Primary Teachers Project has informed the production of the new initiative: 'Primary Teachers Learning Science'. The first presentation of this course is in September 1995 and, based on levels of interest expressed by July, 1995, widespread participation is expected from Local Education Authorities throughout England. An account of this venture forms part of the programme of workshops at the Conasta 44 Conference, 'Science Teaching: an International Perspective'.

There should be a follow-up session for Headteachers to discuss how a science policy is to be implemented and the course work built on. Additional sessions of twilight tutorials and support work in school should be planned for course participants by advisory staff who have team taught the course in conjunction with Open University staff, as should opportunities to study extension modules not covered in the 20-day programme, e.g. Simple Biochemistry and Organic Chemistry, Building a model of the interior of the Earth using earthquake waves and the Origins and evolution of the Earth and atmosphere.

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